TOPOGRAPHIC CORONA GRAVITY SURVEY RESULTS R. L. Comstock[1], S. E. Smrekar[2], and F. S. Anderson[2], [1]Central Washington University, 400 E. 8th St., Ellensburg WA 98926, [2]Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Dr., MS 183-501, Pasadena CA 91109.

Introduction: The gravity signatures of 34 Venusian topographic coronae (previously termed stealth coronae [1]) have been examined from a database of 134 features [2]. Coronae are volcano-tectonic features defined by circular fracture annuli with an average diameter of roughly 300 km [3]. They have been interpreted as small-scale mantle upwellings, and can display a range of topographic profiles [3,4]. Topographic coronae exhibit a similar range of topographic morphology, but lack complete fracture annuli, rendering many difficult to observe in the Magellan radar images. Analysis of the admittance spectum, the ratio of gravity and topography as a function of wavelength, allows for discrimination between compensation mechanisms and determination of lithospheric properties. Admittance studies provide estimates for local elastic thickness (Te), crustal thickness (Zc), and lithospheric thickness (Zl). We employ two methods for generating admittance spectra, an FFT approach [e.g. 5,6,7], and a wavelet approach [8]. Comparing estimates derived from each method we intend to both characterize the utility of each, and to provide a check for resulting elastic and crustal thickness estimates.

Admittance Method: We use both an FFT and a wavelet approach [8] to calculate admittance spectra for each corona in the database large enough to be resolved relative to the local error in the gravity data. The first approach uses local, Cartesian subsections of the spherical harmonic gravity and topography data sets. An FFT is used to transform the data sets into the wavenumber domain. The ratio of the gravity to topography as a function of wavelength is described over the region by binning the observed data points (minimizing error), and plotting them as a function of wavelength. The wavelet admittance spectrum is derived directly from the spherical harmonic gravity and topography fields, averaging wavelength power beginning at a central point, and moving outward in annuli of variable width [8]. The degree of correlation between spherical harmonic fields is used as the error.

Both methods have distinct advantages. The FFT approach has advantages of speed, a long history of interpretation, the ability to use the highest resolution data available in a region, and a well-defined error description. The wavelet approach has the advantage of being easily automated, and has been used to generate a global map of admittance [9]. For each 1° by 1° latitude, longitude point an admittance spectrum has been calculated with its center at that point. This map can be used to examine the variability in the admittance at each corona- another advantage of the wavelet method. Although there is a great deal of overlap in the spectral content for two adjacent points, calculation of the admittance at each point is effectively a sliding filter. Only the short wavelength information changes significantly from point to point. One disadvantage of the FFT method for small features such as coronae is that the smallest region that can be examined is roughly 1200 by 1200 km. Thus the admittance spectra may reflect the signature of features other than that of the corona itself. From this global wavelet admittance map we extract a $16^\circ \times 16^\circ$ region and group similarly shaped admittance spectra into representative classes using a commercial spectral analysis package ENVI [10]. Those classes geographically associated with the corona are averaged. This mean class spectrum is fit with compensation models using the wavelet method. The resulting estimates of lithospheric properties from the FFT and wavelet methods are compared.

The shape of the admittance spectrum is then used to distinguish between isostatic and flexural compensation mechanisms. The presence of bottom loading is reflected in the admittance spectrum as a decrease in spectral amplitude at shorter wavelengths, while the presence of top loading produces an increase of spectral amplitude at shorter wavelengths. Bottom loading refers to the presence of a buoyant, subsurface density anomaly uplifting the lithosphere from below. Top loading describes the mechanical response of the elastic plate to a surface load, such as that of a mountain or volcano. For the case of isostatic compensation surface topography is supported by adjustments in crustal thickness. The isostatic admittance signature is also characterized by an increase in spectral amplitude at shorter wavelengths, but with less curvature than for top loading. The application of appropriate compensation models to observed spectra constrain lithospheric structure by identifying that set of parameters (Te, Zc, Zl) providing the tightest fit to the observed admittance spectrum. Additionally the type of loading can be understood in terms of coronae formation processes and the configuration of the lithosphere [11].

Comparison of Methods: The first task is to determine if the FFT method, in which the gravity and topography have been averaged over a 16° by 16° region, is representative of the corona itself. From examination of the spectra in the global wavelet admittance map, 12 coronae (in addition to the 34 currently in the survey) were identified for which the FFT spectra were not representative of the coronae themselves.

Of these, perhaps half might have been mistakenly used to represent the corona signature if the wavelet method had not been used as well. Many of them had FFT spectra too poorly constrained to fit.

The second task is to compare the derived values of elastic, crustal, and lithospheric thickness. For the 17 coronae that have been examined under both wavelet and FFT approaches, the results are in excellent agreement. Of the 12 topographic coronae with wavelet and FFT bottom loading fits, three provided identical estimates for elastic thickness, and the maximum difference between estimates was 10 km. Similarly, of the seven topographic coronae for which both approaches have been applied to top loading fits the maximum difference between elastic thickness estimates was 10 km. This variation in the results from the two methods is within the uncertainty in the estimates. Similarly, the derived values of crustal and lithospheric thickness agree to within the uncertainties in the estimates.

Use of both methods leads to a more robust result. The wavelet method ensures that the signature of even small-scale features such as coronae can be correctly identified. One disadvantage of the wavelet method is that the width of the filter at short wavelengths causes averaging over a broad range of wavelengths and does not permit interpretation of the data out to the full resolution. Another disadvantage with the way the error estimates are currently implemented in the wavelet approach [8, 9] is that a single best fit model is determined, rather than a range of models allowed within the full error in the admittance. The FFT method does not have these disadvantages. If the FFT error was not used, those spectra that can be equally well fit with isostatic and top loading models might have been fit with a single compensation model using the wavelet approach alone. With the FFT method it is possible to correctly interpret those spectra with a split between the long and short wavelengths. In the wavelet approach, the smooth admittance spectra mistakenly give these areas the appearance of a region that is bottom-loaded.

Summary of Results: Of the 34 topographic coronae with well defined spectra, 17 showed evidence for bottom loading only, five for bottom loading and top loading or isostasy, and 12 for top loading or isostasy only. The range of elastic thickness estimates are 15-57.5 km for bottom loading (mean of 35.4 km), and 10-55 km for top loading (mean of 22.6 km). Crustal thickness estimates for isostatic compensation range from 15-60 km (mean of 36.8 km), and 10-35 km (mean of 23.1 km) assuming the presence of top loading. These ranges of elastic and crustal thicknesses are consistent with previous studies of other coronae [12,13]. Differences in estimates of elastic thickness for top and bottom loading are probably due to a combination of the differences in the two models and the nature of corona forming processes. A top loading fit tends to emphasize the regions with the most power in the data, and assumes no contribution from strength in the mantle [e.g. 6, 14]. The result is that values of elastic thickness are biased toward smaller values. Additionally, since coronae are believed to form over small-scale mantle plumes, some local thinning of the lithosphere may take place.

Interpretation and Conclusions: The range of elastic thickness estimates for both topographic coronae and other coronae are virtually identical, indicating the general similarity in the lithospheric structure and scale of upwelling that form the two groups. This suggests a nearly uniform lithospheric thickness globally, which may be consistent with a uniform resurfacing age. The variations in elastic thickness and crustal thickness may be primarily a result of the corona formation processes rather than of regional variations. As with most coronae characterics, the variations in the gravity loading signature or derived parameters do not correlate with other corona characteristics, such as diameter, geologic setting, and topographic group [4].

There is good agreement in crustal, lithospheric, and elastic thickness estimates between wavelet and FFT approaches. While the FFT method is much faster, it can be sensitive to gravity associated with adjacent geologic features, tainting the spectral signature of the corona under investigation. The wavelet method is useful in isolating coronae gravity signatures, but does not currently have a description of error that is useful for this application, does not allow for interpretation of the full resolution data due to the filter width, and proves to be computationally intensive. Use of the two methods in combination results in a more robust determination of the signature of individual coronae.

References: [1] Tapper et al. (1998) *LPSC XXIX Abstracts on CD-ROM.* [2] Stofan E.R. et al. (2001) *LPSC XXXI Abstracts on CD-ROM.* [3] Stofan E. R. et al. (1997) in *Venus II*, 931-965, and references therein. [4] Smrekar S. E. and Stofan E.R. (1997) *Science, 277*, 1289-1294. [5] Dorman and Lewis (1970) *JGR*, 75, 3357-3365. [6] Forsyth (1985) *JGR*, 90, 12623-12632. [7] McNutt (1988) *JGR*, 93, 2784-2794. [8] Simons, M. et al. (1997) *Geophys. J. Int.*, *131*, 24-44. [9] Anderson, F.S. and Smrekar, S.E. (2001) *LPSC XXXI Abstracts on CD-ROM.* [10] Research Systems (1999), *ENVI Users Guide, Ver. 3.2*,56-565. [11] Smrekar, S.E. and Stofan E.R. (2001) *LPSC XXXI Abstracts on CD-ROM.* [12] Johnson, C.L. and Sandwell, D.T. (1994) *Geoohys. J. Int.*, 119, 627. [13] Smrekar, S.E. and Stofan, E.R. (1999) *Icarus*, 139, 100-115. [14] Petite, C. and Ebinger, C. (2000), JGR, 105, 19,151-19,162.